The Neutrino Burst Experiment
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Gamma-ray bursts, observed in satellites near Earth at a rate of ~1 per day, are believed to be among the highest energy phenomena known. The relativistic fireball model is consistent with all the major observed features of gamma-ray bursts (GRBs) and has been used by Waxman and Bahcall to predict a measurable flux of ~10^{14} eV neutrinos, much more energetic than laboratory neutrino sources. According to this model, a detector of ~1 km^2 effective area will observe ~20 neutrino-induced muons per year in coincidence with gamma-ray bursts. The Neutrino Burster Experiment (NuBe) will test the fireball model stringently and uniquely , with an inexpensive, quick, and robust experiment.

NuBE is a water Cherenkov detector whose simple design derives from the constraints imposed by requiring coincidence with measurements of the photon arrival time and the GRB location provided by detection in satellites. The mean energy of the neutrinos in the fireball model is 10-100 TeV, which leads to Cherenkov signals detectable with high efficiency at large distances from the core track. A muon core is formed when the muon-neutrino interacts in material within ~10 km of the array, leading to a highly radiative muon observable with high efficiency at perpendicular distances >150m from the core along its multi-km length. An electron neutrino has a core track which is itself only a few meters in length, but the light from this short core is intense and may be seen by the proposed array at distances in excess of 500m.

The 4π NuBE detector approximates a sphere of diameter >600m, creating an effective area of >1 km^2. The detector consists of four strings placed in the clear water of the deep ocean with their anchors at the corners of a square having >300m sides. Each string has two photon-detector nodes separated by >300m along the string. Each node acts independently of the other 7 nodes in the array, having its own local trigger and data acquisition and storage, thus providing robustness and redundancy. Local node clocks are periodically synchronized using bright flashes of blue light from calibration spheres at the center of each string. Absolute time is kept via these local clocks to accuracy of better than 10s per year. A signal consists of a locally triggered event in any node occurring within 3 μs of a locally triggered event in at least one other node, with this coincidence determined off-line. The direction of time difference gives the incident track direction providing robust verification of any signal falling in the correct time window. The electronics connecting the photomultiplier to the data acquisition is straightforward.

Much of the detector can be assembled from “off-the-shelf” items; anchors, strings, and housing spheres are items of commerce familiar to many of our collaborators. Deep-sea rated battery packs can provide >1 year of untended operation. The detector is easy to deploy and to recover in any of a variety of locations, since it doesn’t require accurate positioning. It should be placed near the equator to have a clear view of the whole sky. Placing the strings in location at a site off the coast of St.Croix in the US Virgin Islands can be done easily by vessels of opportunity or with minimal schedule lead time. This site has the additional advantage of providing 4km deep water within 15km of the shore, a clear virtue for site visits and data retrieval. Deployment details include the plans for an early test of optical properties at the site (which determines node separation), deployment of a single test string for 3 months, and deployment of the four-string array for at least 1 year.

NuBE provides >1km^2 collecting area in its 4-string implementation and can tell us quickly whether the fireball model is correct in its predictions of high energy neutrino bursts. The total project, from initial approval to completion of data analysis, will take <3 years and cost <$3M.